THE GLOCHIDIAL CONGLUTINATES OF THE ARKANSAS FANSHELL, CYPROGENIA ABERTI (CONRAD) [1]

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The successful transfer of ripe glochidia from the maternal marsupium to the gills of the proper host fish constitutes one of the critical events of the life cycle of the fresh-water mussel. The difficulties of this transfer, which is accomplished largely as a matter of chance, are offset by the production of enormous numbers of glochidia, rather than by special structures or devices. It is, therefore, of interest to find a species of fresh-water mussel, *Cyprogenia aberti* (Conrad), the Arkansas fanshell, which has developed a special type of conglutinate that apparently serves to lure fish, since these conglutinates readily attracted fish, and when eaten by fish produced glochidial infections on the gills of these fish.

On February 2, 1932, a bright red, worm-like object about 1 mm. in length was observed projecting approximately 1.5 cm. from the exhalent syphon of the specimen of the Arkansas fanshell, in one of the experimental tanks. This mussel and others, both of the same and different species, which had been collected from the St. Francis River, Arkansas, during the preceding September and shipped to the laboratories at the University of Missouri, were living undisturbed in sand at the bottom of a large hatchery tank through which fresh water was constantly flowing. The anterior end of this red object was expanded into what appeared to be a definite cephalic portion and the whole structure occasionally waved back and forth. When removed from the mussel this object was found to be over 3 cm. in length and to be composed of glochidia in various stages of development, that is, the whole was a single glochidial conglutinate. The expanded "head-like" portion (Figs. 3 and 4) was pierced by one large opening, which in some specimens subsequently observed was more or less subdivided by masses of glochidia. On examination under the microscope it was found that the entire outer surface of the conglutinate was covered with ripe, fully-formed glochidia and that the central axial portion was made up of embryos and incompletely developed glochidia. The red color of the entire conglutinate was due to these central embryos, which contained more or less bright red material, the amount of the red substance vary-

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ing inversely with the degree of development of the embryo. The mature glochidia were colorless, very transparent, and gave the outside of the conglutinate a frosted appearance. At the anterior end of this worm-like conglutinate, that is, the end first extruded from the mussel, the mature glochidia were found only on the outside, but they increased in numbers toward the posterior end of the conglutinate, which was composed almost entirely of mature ripe glochidia. The terminal portion (Fig. 5) of the posterior end of this conglutinate, therefore, had a white translucent appearance owing to the absence of the red immature embryos. The color of the entire conglutinate was, however, predominantly red, shading through light red to pink near the posterior end. On comparison with Ridgways' Color Standards (1912), the color of the conglutinate was noted as varying from garnet brown at the anterior end to nopal red near the posterior end. The measurements of five expelled conglutinates are given below (Table I).

TABLE I

Dimensions of Expelled Conglutinates in Millimeters

Length of entire conglutinates	Minimum diameter	Maximum diameter exclusive of "head"	Width of "head"	Length of "head"
33.34	0.49	1.17	1.28	2.21
23.64	0.54	1.00	1.46	1.90
21.60	0.39	1.11	0.97	1.96
51.82	0.59	1.11	1.79	3.04
26.84	0.78	1.20	2.10	3.12
Average: 31.45	0.56	1.12	1.52	2.45

After discovering the first extruded conglutinate, 17 additional female specimens of *Cyprogenia aberti* were brought under observation and each of these individuals subsequently extruded red worm-like conglutinates. The ejection of a single conglutinate required from 3 to 12 hours and as far as was observed was not correlated with any particular external stimulus. When completely extruded the conglutinate fell to the sand alongside the mussel where it remained unless moved about by water currents. Within three or four days after the extrusion from the body of the mussel, undisturbed conglutinates at the bottom of the tank lost their color and the mature glochidia when examined were found to be weak or dying, as shown by their closing reactions when tested with physiological salt solution.

Sterki (1898) in a discussion of the anatomy of the closely related species of fresh-water mussel, *Cyprogenia irrorata* (Lea), noted the

worm-like appearance of the conglutinates lying in place in the marsupial portion of the gill and described these conglutinates as worm-like cylinders which could be extracted *in toto* from the enclosing membrane. On dissecting gravid specimens of *Cyprogenia aberti* (Conrad), the writer noted the curved position of the marsupium which is characteristic of species of this genus and the arrangement of the conglutinate as figured by Ortmann (1912). When the marsupium was in place, the anterior or head-like portions of the ripe conglutinates were found to be formed by masses of glochidia lying in the top of each marsupial compartment at the point where this compartment joins supra-branchial passage. The flat posterior portion of the conglutinate filled the outer or distal section of the marsupium (see Figs. 6 and 7). During the extrusion of the conglutinate the entire structure was forced first into the supra-branchial passage and from there on out through the excurrent siphon.

The question arises whether the extrusion of these conglutinates as described in the specimens of the Arkansas fanshell is a normal procedure or whether it was merely a case of abortion. Lefevre and Curtis (1912, p. 137) state that "in *Obliquaria reflexa,* however, the conglutination persists, and the fully developed glochidia, still tenaciously adhering, are discharged from the marsupium in the cylindrical masses already described." These authors figured the expelled conglutinates of this species as curved cylindrical masses which they state "do not disintegrate even after lying in the water for some time." As *Obliquaria reflexa* and *Cyprogenia aberti* are rather closely related species, it would seem in view of the findings of Lefevre and Curtis that the extrusion of conglutinates by *Cyprogenia aberti* was not an abortion, particularly since these worm-like conglutinates of *Cyprogenia aberti* were covered with mature ripe glochidia which gave vigorous closing reactions when tested separately.

To eliminate the possibility of abortion or abnormal discharge of the conglutinates a second shipment of *Cyprogenia aberti* from Arkansas was made early in September, 1932, care being taken to insure the minimum disturbance of the mussels while in transit. As soon as these specimens arrived they were placed in a specially prepared hatchery trough through which fresh water flowed continuously and on the bottom of which was a layer of sand some 8 inches deep. The fanshells soon established themselves in the sand and as far as could be determined remained in good condition. Individuals of several other species of mussels were carried in this trough as controls and all mussels in the trough lived throughout the winter.

On February 15, 1933, the first red conglutinate was extruded from

one of the specimens of the *Cyprogenia aberti,* and the spawning of this species continued during the next four weeks. Each female during this period extruded from 6 to 20 conglutinates. As these animals had not been disturbed since their arrival in September, that is, some five months previous, and as there had been no deaths in the group, nor among the control series of other mussels, it seems that this extrusion of conglutinates by the *Cyprogenia aberti* is a normal procedure and not an abortion due to some abnormal condition, particularly since the spawning period began in February both years.

As continuous thermographic records of water temperature were taken throughout the entire period these animals were under observation, and as the dissolved oxygen, carbon dioxide, carbonates, and pH were determined at regular intervals, correlations with the physical and chemical conditions of the water and the onset of the spawning period were looked for. Of the factors determined, temperature was the only one showing a significant change near the onset of the spawning activities.

The temperature charts showed that the average water temperature in the hatchery tank fell slowly through September to January, from 20° C. to 16° C. and that during February the average temperature rose rather rapidly to about 19° C. In view of the known relationship between temperature and spawning time of various other aquatic animals, and this rise in water temperature which occurred both years in February, it seems that the spring rise in water temperature is at least a contributing factor in initiating the spawning activities of the Arkansas fanshell.

Having established the fact that the formation and extrusion of these queerly shaped conglutinates are normal activities in this species of fanshell, and in view of the striking resemblance of these conglutinates as

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Explanation of Plate I

Fig. 1. A single expelled conglutinate of *Cyprogenia aberti* (Conrad), showing ripe glochidia on the outside. Some free glochidia may be seen near the conglutinate.

Fig. 2. Five expelled conglutinates. Note the frosted appearance of the posterior portion of each due to the covering of ripe glochidia. Numerous free glochidia may be seen.

Fig. 3. Side view of anterior portion of conglutinate.

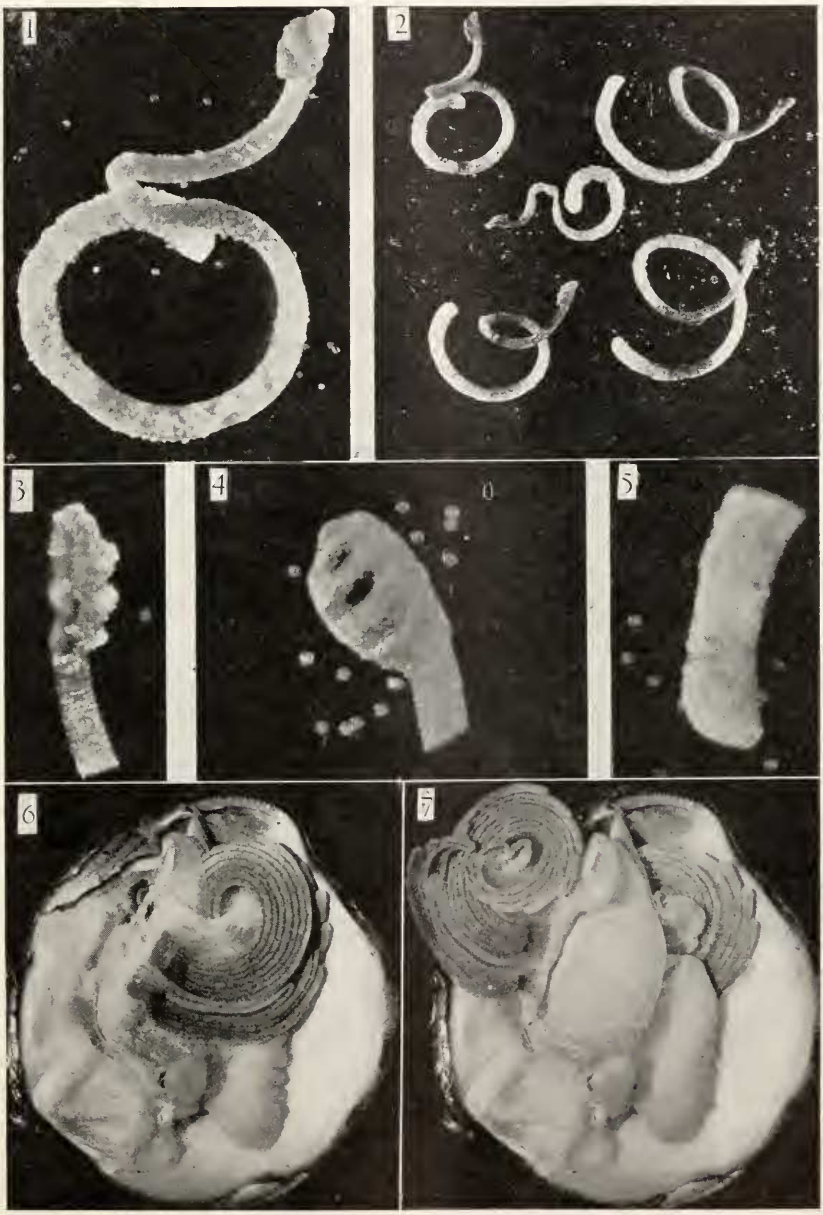
Fig. 4. Top view of anterior portion of conglutinate.

Fig. 5. Terminal part of posterior portion of conglutinate.

Fig. 6. Entire mussel lying in right valve. The left valve and left mantle have been removed. The arrangement of the conglutinates in the outer or marsupial gill can be seen.

Fig. 7. Same mussel as Fig. 6. The left marsupium has been raised, exposing the inner gill, and below the lower half of the right marsupium.

PLATE I



they waved back and forth from the exhalent syphons to tubificids or other bottom-inhabiting worms, some experimental tests were made to determine the reactions of fish to these brightly colored conglutinates, both during extrusion and after separation from the gravid mussel. Single individuals of gravid *Cyprogenia aberti* were placed in large glass battery jars, through which fresh water flowed continuously and which contained suitable layers of sand at the bottom. After the mussels had burrowed into the sand and were properly established, the extrusion and discharge of the red conglutinates proceeded as before, a medium-size goldfish (circa 3 inches long) was then placed in each jar and the reactions of the fish carefully noted. In every case the fish greedily ate any exposed conglutinates. The fish quickly seized incompletely extruded conglutinates and pulled them out of the exhalent siphon of the gravid mussel, and also picked up any discharged conglutinates lying on the bottom of the jar. Discharged conglutinates were readily eaten by other goldfish when placed on the bottom of the tank in which these fish were kept. As all of the fish used in these experiments were well fed, the avidity with which these fish selected and ate the conglutinates must be charged to a normal and not to a starvation reaction.

The goldfish which had fed on conglutinates were killed at intervals of from 15 minutes to 5 hours after the ingestion of the conglutinates. In every case glochidial infections on the gills were noted. Apparently the ripe glochidia, which are easily loosened from the outside of the conglutinate, attach themselves to the gills of the fish while the conglutinate is in the process of being swallowed. From these experimental findings the value of these brightly colored conglutinates to the species in the transfer of glochidia from gravid female to a host fish is evident.

The axial masses of immature glochidia and embryos passed on into the stomach, where they were rapidly disintegrated by the digestive juices in the course of an hour and a half. Fragments of glochidia were found in the duodenum five hours after the conglutinates were taken into the mouth.

These observations on the conglutinates of *Cyprogenia aberti,* and their usefulness as a device for the transfer of glochidia to the host fish, strengthen the suggestions of Coker, Shira, Clark, and Howard (1921, p. 85) concerning the function of the mantle flaps in the pocketbook, *Lampsilis ventricosa.* These writers state that "the conspicuous flaps which sometimes suggest the appearance of small fish, may serve as a lure to fish, bringing them into desirable proximity to spawners when glochidia are ready for extrusion." In this connection it may be added that in several species of fresh-water mussels belonging to the *Lampsilinæ* the marsupium and mantle margins in gravid females are more or

less brightly colored with black, brown, or yellow, the gravid marsupia being partly extruded at times by these mussels. These colored structures may also serve as fish lures.

Summary

1. The brightly colored worm-like conglutinates of *Cyprogenia aberti* (Conrad), the Arkansas fanshell, are described.

2. Experimental evidence is offered showing that these conglutinates serve as fish lures and thereby aid in the transfer of the ripe glochidia from the gravid female mussel to a host fish.

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